The Province of Alberta

PETROLEUM AND NATURAL GAS CONSERVATION BOARD

IN THE MATTER OF THE GAS RESOURCES PRESERVATION ACT

AND IN THE MATTER of a Joint Hearing to determine various questions relating to the proposed Export of Natural Gas from the Province of Alberta.

I. N. McKinnon Esq., Chairman

D. P. Goodall Esq.

Dr. G. W. Govier

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W I T N E S S E S

E X H I B I T S

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MR. STEER: Mr. Donald is here, sir.

JAMES RICHARDSON DONALD,

having been first duly sworn, examined by Mr. Steer, testified as follows:

Q What is your occupation, Mr. Donald?

A I am a chemical engineer by profession. I graduated from McGill University in 1913. I have been actively practicing my profession since that date.

THE CHAIRMAN: Mr. Steer, I think we will accept Mr. Donald's qualifications.

THE WITNESS: Thanks very much.

Q MR. STEER: And have you read the brief of the Alberta Research Council?

A Yes, sir.

Q You have read it?

A Yes. I have read it with a great deal of interest and my views generally coincide with theirs. I think it is a very excellent statement of the facts. My only criticism of it is that I think they have been much too conservative in their estimate of the possibilities of the expansion of industry in Alberta based on gas. In my opinion, Alberta's position in the Canadian economy is unique, not only are their resources very varied and extensive, as pointed out in the Research Council's brief, but Alberta is the only Province in Canada which has a

substantial production and reserves of petroleum and natural gas. Based on these, and more particularly the petroleum and natural gas, the industrial possibilities are very great, particularly in the field of petroleum chemistry, which has come to be commonly known as the petro-chemical industries.

Q What are some of those possibilities that you have in mind, Mr. Donald?

A Well, in the first place, those products of industry or those industries with large heat requirements, that natural gas offers very definite advantages. Cement manufacture, glass manufacture, ceramics industries, may logically be expected to be expanded or initiated. The possibility of metal smelting and refining is also important. The expansion of uranium mining may lead to the processing of uranium ores here. New processes for the treatment of copper and nickel ores have been developed, which uses ammonia for raw material and in addition has a substantial heat requirement. The availability of ammonia and natural gas here might lead to the establishment of such an industry here. Then there are the more truly chemical industries, for example, there has already been established here the large synthetic ammonia plant which uses natural gas on a large scale, and based on their processes further expansion in the chemical field is possible. For example, it would be very logical to produce methanol and urea. Markets for both these products are increasing, and they, in their turn, make possible the manufacture of plastics and other such

materials. It is not at all illogical to conceive that the ammonia operation itself may be expanded. At the end of the war we felt that these ammonia plants would have much too great capacity for demand but our pessimism has proved to be unwarranted and ammonia actually is in short supply.

A salt plant has been established using natural gas for fuel in the Province, and a very logical expansion there would be the manufacture of caustic soda and chlorine, for which there is an expanding market in the Province. Chlorine is very widely used in the chemical industry and makes possible the production of a wide range of products. Currently an explosive plant, I believe, is being established here, and the fact that it is reflects the increasing activity in the Province in demand for explosives, and in addition the facilities that exist here in the form of ammonia and the very satisfactory fuel situation.

Another is sulphur, which is available from your natural gas, and that makes possible sulphuric acid, widely used in chemical processes. If this plant makes its own acid they may use some of that sulphur for their explosive requirements. Another very interesting and important possibility from the oil fields here is the production of benzine and tolerene. These were formerly obtained from coking operations but they are obtained from petroleum and can be synthetized from the petroleum industry. Benzine is the essential product for the production of styrene,

which is an essential ingredient in the manufacture of synthetic rubber and plastics. Benzine is the basis for synthetic phenol, which is being required in increasing quantities in this country. Propane and butane are now becoming available in this Province in substantial quantities and they are a source of ethylene. Ethylene in turn is a source of a very large range of chemicals. Ethylene glycol, the well-known anti-freeze, and polyethylene, are two of the more important. A new use for ethylene is the manufacture of polyethylene, which is being used as a film. An extremely rapid expansion in the manufacture of polyethylene will likely be undertaken in Canada before long, not necessarily in Alberta but in Alberta there are the raw materials which would prove very attractive to anybody considering this. Another interesting point is that ethylene is a source of synthetic ethylalcohol, and in the United States about 50% of the ethylalcohol produced is now made synthetically from ethylene.

In the Alberta Research Council's submission they referred to the possibilities of the production of oxygenated organic chemicals such as methanol and formaldehyde. These processes are very large users of natural gas and propane-butane mixtures. If such a development is to take place in Canada, the only possible location would be in this Province.

Now, using these basic chemicals which we have been talking about, you then come to a wide range of subsidiary products which have

a very direct application. Among the more important are the new insecticides and weed killers, that is, products like DDT and 24D. They have already revolutionized agriculture and are finding a rapidly expanding market. It is not at all inconceivable that the expansion of the market in Western Canada may lead to their production.

Another interesting group of products are the synthetic detergents. Those are suitable for hard water areas such as exist in the Canadian West and their importance is best illustrated by the fact that in the United States they have now taken over about half of the soap market. I think an expanding market in Alberta for such products can be expected.

Another very wide user of petroleum chemicals are the synthetic fibres. Petro-chemicals are being increasingly used for the manufacture of nylon and also for orlon, the new synthetic fibre which is rapidly expanding.

I think another point of interest is that you have here in Alberta all the raw materials necessary for a synthetic rubber industry, for a major increase in synthetic rubber required in this country. For example, if duplication of the Sarnia plant were required, it would be a logical development by Alberta and undoubtedly would be seriously considered.

I do not wish to continue to possibly bore you with these things, but this is the type of picture which is open to the Province of Alberta with the resources they have got.

Q Open within what length of time?

A Well, that is the question. These developments, or some of them, require very large capital investments and the markets have to be exceedingly well-defined to justify the developments. Canadian markets are relatively small compared with those in the United States. However, the increasing demand for such products as insecticides, weed killers, detergents, synthetic fibres, ethylglycol, are such that I think the probable manufacture of some of those will be undertaken in Canada before too long. If the United States market to the south were opened up to Canadian manufacture by either lowering or removing of the tariffs, I think some of those would come about very quickly.

About a year ago there was a general easing in demand for chemical products and a good many of us felt we were perhaps coming into a period of over-production. However, the international situation, the U.S. and Canadian armament programs and the Korean war has simply reversed the situation and to-day practically every chemical is short. I do not know what will come out of this recently announced agreement between Canada and the United States for mutual cooperation for war production, which is similar to the Hyde Park agreements of the last war, but the basis of the agreement is that the natural resources of the two countries shall be used to their greatest mutual advantage. I think it can be stated without contradiction that if we are again faced with a major war effort there would

undoubtedly be a substantial expansion of chemical industry in Alberta. Benzine, tolerene, sulphur, there is everything necessary for an explosive industry, and we would also bring heavy demands on ethylglycol, benzine, glycerine, a long list of chemical materials. What the course of events would be it is almost impossible to predict, but I think that anybody who knows the chemical industry and recognizes the fact that its growth is more rapid than the average of industry can not but be optimistic as to the possibilities of chemical industry expansion in Alberta.

Q What quantities of natural gas and other petroleum products are involved?

A Well, that is quite obviously based on the plans for development. However, as an example, a reasonably sized unit for the production of methanol would be 4 tons a day, would require about 2 million cubic feet of natural gas per day. That is the order of these things.

If an oxygenated organic production were undertaken on a reasonably economic scale, natural gas in the order of 20 million cubic feet would be required together with large quantities of propane and butane. Other products would require extensive quantities of propane and butane and extensive quantities of natural gas as a source of heat, but to make any general estimate of what these requirements would be is a pretty difficult matter, except as time goes on there will be an increasingly large requirement.

Q What is your view on the question of freight rates, Mr. Donald?

A Well, the main barrier to the shipment of chemicals, say from Alberta to Eastern Canada are the freight rates. However, they are not as serious as might first seem. For example, in the case of ammonia it is generally felt that ammonia produced in Alberta can successfully compete with ammonia from Ontario with its relatively high cost fuel, and I think that is correct in products such as rubber, sythetic fibres, things of that sort, which are in the high priced chemicals and the freight rate is not an insurmountable barrier.

Q What is your idea of the capital investment required?

A Well, the investments in chemical industries always are heavy per unit of production. These figures may be of some interest to you. About 85% of the petrochemical industry of the United States is located in the South-west within a radius of about 200 miles from Houston. Pre-war investment there was about $65,000,000.00. During the war an additional billion dollars was invested and since the war something like another half billion has been invested or is being invested. Now, if you assume a ratio of 10 to 1 for the population of the United States to Canada, similar development in Alberta would involve capital investment of $150,000,000.00. Now, allowing a much lower rate you would still have a very substantial investment figure. If the United States markets were open I think the investment might be relatively larger to the Canadian economy than the Texan or the U.S. South-west investment.

Q It has been suggested that this gas has been here for a

long time and we have not seen any of this development, Mr. Donald. What is your comment on that?

A Well, I think that is pretty obvious. The whole development of industry based on natural gas is of comparatively recent development. There was practically none in the United States prior to 1930. Expansion has mainly been since 1939. Our Canadian economy always lags in those things behind the United States economy. Another factor, I think, in the situation here is that these substantial quantities of propane and butane have only recently become available as a development of the oil fields in the last year or two, and they are an essential raw material for much of the petrochemical industry. I think it is only fair to say that it is only recently that the broad base for petrochemical industry has been established and the development should, from now on, be fairly rapid.

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Q And what have you to say with regard to the importance of gas reserves in relation to these industries that you are speaking of?

A Well, the long term investments and the large investments required for chemical manufacturers to be attracted, raw materials and natural gas reserves for a period of at least 25 years or longer would have to be assured. I think the position one must take, while it is impossible to predict how rapidly Alberta industries will develop, it can be confidently predicted that there will be a substantial chemical industry development in Alberta, and if there is a national emergency it will be very much accelerated. I think obviously the gas reserves and the gas invaluable. Currently there is a good deal of activity in the investigation, activity and investigation of the possibility of the establishment of new chemical industries in Alberta. And, more recently, several groups have been studying them, and I happen to be familiar with the work they are doing.

Q Have you, in your consulting practice, have you any knowledge of any recent interest in this question?

A Yes, we have had recently, as I have said, several inquiries which are being followed up relative to the possibility of establishing a chemical industry here on a very substantial scale.

Q Now, if Alberta's surplus gas were put into surplus, what would be the effect on the development of this petrochemical industry?

A Well, obviously, unless you have gas available here, and an assured supply of it, you will not have industries

come here and make the necessary investment. Another factor that comes in is that I think it is true to say that if Alberta gas were available in the United States at low prices, it would permit the creation of a petrochemical industry based on this gas. Under those conditions the advantages which would accrue if the industries were located in Alberta, and the product shipped to the United States, would be lost. I think perhaps the ammonia plant is an excellent example of the point I am trying to make. This Calgary plant uses some 10 million cubic feet of gas a day, at a cost of about 14 cents a thousand, or a total daily cost of about $1400.00. The resulting production of 250 tons of ammonia a day has a sales value.....

Q I think you said 10 million, Mr. Donald, is that true?

A 10 billion I should have said, I am sorry.

Q 10 billion?

A Yes. The plant produces about 250 tons of ammonia a day, and if you take that at $75.00 a ton, which I think is a conservative valuation, you get an income of about $16,000.00 a day, and as there is no duty on fertilizer a large part of this ammonia is sold as fertilizer in the United States duty free.

Q MR. C. E. SMITH: Excuse me, that 10 billion that you referred to, what was that?

A The Calgary plant - I am sorry, the Calgary plant uses 10 million cubic feet a day.

Q MR. STEER: 10 million?

A Yes. I confused myself. I was confused with the yearly figure Now, if that ammonia plant were located over the

U.S. border, the only income that Alberta would get out of the gas would be $1400.00 a day at the current price. Now, the advantage to Alberta is the difference between $1400.00 a day and $16,000.00 a day, and that is generally true of the chemical industry.

Q Have you looked at the Canadian Western curve showing estimated future sales?

A Yes, I saw those curves.

Q What is your comment on that?

A Well, I am inclined to feel that they do not reflect the growth in the market for natural gas which can be anticipated. The great tendency in our modern civilization is to use increasingly large amounts of energy per unit of population. Now, in the electrical industry, the load is expected to double about every ten years. An assumption that the gas demand in Alberta would double in about 10 years, in about every 10 years, does not seem to me to be unreasonable, taking into consideration the factors of population growth, expanding use, and industrial development.

Q Thank you.

....

CROSS-EXAMINATION BY MR. FENERTY:

Q Mr, Donald, I was interested in your statement that most of the industries that we have been talking about from time to time, chemical industry, based on gas as a raw material, they have originated or increased largely since 1939. My understanding is that in the United States there were numerous gas lines carrying supplies of gas to centres of industry prior to that time, is that correct?

A I really cannot tell you very much about that. I am sorry. I know there were gas lines, but I do not know the details of it.

Q There were gas lines?

A Yes.

Q I am interested in this suggestion, for instance, my learned friend, Mr. Smith, advanced that nylon was not being manufactured in Texas, and I suggest to you that the reason it was not being manufactured in Texas is because there were sources of supply of gas at the other end of gas lines from Texas, from which they could be manufactured.

A Well, I do not think that is correct. Well, you see that nylon came.....

Q Yes?

A .....into industrial production in the early stages of the war, and it was originally based on coal.

Q Yes?

A And a very large part of the nylon salts which are used in making the resin which is eventually spun into nylon is produced in the southwest.

Q MR. McDONALD: That is, the salts are produced?

A Yes.

Q MR. FENERTY: Perhaps nylon was an unfortunate illustration. I wanted to get at the making of nylon, but it may not be, however, nylon was one of the things mentioned by a witness, and I was interested in that, and what I am going to suggest is that the situation here in Canada is quite different from that in the States where there are sources of supply of gas, whether used for raw material or otherwise, at centres of manufacture from

existing pipe lines, that is correct, isn't it?

A You are referring to the gas being available at the eastern seaboard?

Q Yes?

A Yes.

Q It is available at centres?

A Yes.

Q And, therefore, anyone who wants to engage in chemical industry and use that gas has it available in areas where there are low freight rates and various charges, low freight rates, I mean, and various advantages, and I gather, if we are going to look at the past, as I think many of my friends have been doing, instead of the future, as I am trying to do, that to judge from that, if gas is exported from Alberta, in view of our high freight rates and so on, it will necessarily be used in centres of manufacture for chemicals where they have other advantages we haven't got, that seems reasonable, doesn't it?

A Well, it is not the history. The history is that the chemical industry has been rapidly moving from the eastern seaboard to the U.S. southwest, as these investments that I quoted to you indicate.

Q If that is the case I do not need to elaborate my theory. But let us assume for a moment or so that some of our friends are correct, and that you do not get these industries at the sources of supply, and you get them at the centres of manufacture, and that we cannot hope for them here because of the high freight rates and so on, now, what I am suggesting to you, and I wonder if this appeals to you as reasonable, forgetting your own

knowledge of the fact that industries are moving west towards the source of supply, and assuming, as some of our friends assume, that they will necessarily stay elsewhere, and that we are under a disadvantage of high freight rates, I suggest to you that this is correct, export would necessarily mean that we will not have any industries, and if we do not have export, there being no source of supply, no other source of supply, this is the only place they can manufacture within Canada. Is that a reasonable supposition to you?

A I do not think it is altogether correct. Industries of different types - if you take nylon, for example. There is a plant that spins nylon in Kingston. It takes this resin and prepares it and makes the fibre, but the raw material for that is coming at the present time from the United States. Now, that raw material could equally well come from Alberta.

Q I see. Notwithstanding the freight rates?

A I do not think the freight rates would interfere because, as a matter of fact, the raw materials are coming from Texas right now.

Q I see. You think, then, that the freight rates would not be a deciding factor at all whether or not industries located here?

A Freight rates are a large barrier and will be to some types of production.

Q Yes?

A But there are a good many products in the petrochemical field which there will be a market for here, and there are others which are of high cost in which the advantages

here will offset the freight rates.

Q I see.

A I mentioned ammonia as a typical example.

Q I am trying to supplement your statement, and I am not getting very far.

MR. C. E. SMITH: You should tell him you are not against him, maybe you would get along better.

Q MR. FENERTY: As a matter of fact, I am in agreement with your testimony, both here and at the Dinning Commission. Perhaps I should have told you that in the first place, and then we might get along more pleasantly, or easily, I should say. What I am getting at is I have heard a lot here, and I am a layman, and my friends are laymen, in the sense of the chemical industry, but we have heard a lot here that the history of natural gas in the United States over a period of many years is such as to indicate that it is totally wrong to suggest that you are going to have manufacturers building at the source, because it did not happen in Texas. Now, you say it is moving southwest at the present time?

A That is totally wrong. It has taken place in Texas.

Q What is that?

A That is totally wrong. It has taken place in Texas, or in the southwest, and the market for the materials produced in Texas is in a large degree outside of that area.

Q Now, apart from that - that is so much the better if that is what it is doing. But, apart from that, I am trying to suggest, what I am trying to suggest, and I want you to tell me whether or not there is anything in it, we are in an entirely different position in Canada, as, so far,

we have only this one source of commercial gas in large quantities up to the present time, and they have many sources in the United States, and, at least, at the present time they have many pipe lines, where, if it is an advantage to do so, they can take the raw material to the centres of manufacture, or the seaboard, where they do not have the impediment we have im the freight rates. Now, I suggest if there is any virtue in these arguments that manufacturers will go elsewhere than the southwest, I suggest to you the United States corollary is that it will take place elsewhere than in the southwest, if you have pipe lines, but it will only take place at the source, because we have that gas here, we have only one area with gas. Isn't that just plain logic?

A Well.....

Q That seems to me to be adding two and two.

A I think you have to qualify it by the types of industry. For example, if you move natural gas quite a long distance you might still use it for the manufacture of cement, but you would never, by any chance, move the cement itself over a long distance. I know the point you are trying to make, and I think perhaps one thing that should be said is that I believe the resources of Alberta in the Canadian economy are potentially - put it another way -that the resources of Alberta in the Canadian economy are more unique than the southwest is in the U.S.A., because it is the only point where we have our gas, but you cannot generalize for industry as a whole the way you are trying to do.

Q I see. If I modify my statement I wonder if you can

agree with me. You will agree with me this far, if you do not export gas and if they want to use it they have to come here?

A That is right.

Q I do not think we can argue much about that?

A Of course, you have got to come back to this, it is not gas that you are dealing with, it is heat units.

Q Oh, we won't argue about that simple proposition, if we do not export it they have got to use it here or not use it?

A That is perfectly true.

Q That is plain enough?

A Yes.

Q If I modify my other statement, perhaps I can get an agreement from you. If you do export it, there are certain types of industry that we might otherwise get that we will lose, and there are some that we will get anyway?

A If you are exporting, is that it?

Q Yes?

A What do you mean by export?

Q Outside of the Province?

A You mean, for example, export for 100 miles or 1000 miles, or what are you talking about? Because it gets back to the cost of the gas.

Q I am talking about these industries that I now understand from you, with your technical knowledge, won't come here, because they could use this gas elsewhere?

A I thought I made that point clear. If this gas went over the U.S.border immediately to the south, that would be export. On the other hand, the value of the cost of the

gas at that point would be no greater necessarily than at Calgary.

Q I am sorry. When I said export what I mean is departing from Alberta?

A Well, it is departing from Alberta if it goes to Montana.

Q But I am talking about the Canadian economy. I do not give a hoot what they build up in the States, providing they do not tear down here. I hope they can do anything they like there, and build as much as they like, but what I am talking about now is the Canadian industry. First, we have the proposition if we do not let it go outside of the borders of Alberta, if they want to use it they have got to come here, that is right, isn't it?

A Yes.

Q I thought that it followed if we did export, on the evidence that my friends have been adducing, that they would not come here, they would manufacture elsewhere, and they pointed to Texas, I know you disagree with it, but they say that industry did not go there, and when I suggested to you that practically all of these industries would manufacture elsewhere, because of the distance that we had, the disadvantages we have here such as high freight rates, you said you could not generalize, that was too general, that there were others that would come here, and some that would manufacture elsewhere, as I understand it. Then I say it follows from that that if we do not export, they have all got to come here, as far as Canada is concerned, but if you do export some may come anyway and others may go elsewhere. Now, isn't that just a plain proposition?

A I think perhaps we could cover the thing this way, that insofar as these chemical industries we are talking about are concerned, I think they are bound to come to the gas.

Q Anyhow?

A Yes.

Q Well, that is fine, thank you.

A Yes, but I do not think it applies necessarily to the cement industry.

Q But as far as the chemical industry is concerned you think they are bound to come?

A Yes, as far as the chemical industry is concerned I think they are bound to come.

Q The requirement being an ample supply of gas for perhaps 30 years, firm commitments for 30 years?

A Well, on that order, yes.

Q On that order?

A Yes.

Q That is what you have got to provide for these industries which are bound to come here?

A Yes.

Q If they can get it?

A Yes.

Q Thank you.

....

RE-EXAMINATION BY MR. STEER:

Q Mr. Donald, perhaps I might ask you this question now, you were going to say something about the cost of gas in Montana, we will say, just south of the border, as not being greater than the cost in Calgary. Did I understand

that?

A What I was saying was that if the distance from the gas fields, say, to the border is about the same as the distance from the gas fields to Calgary, obviously the cost in the United States should, if it were moving freely, cost no more over the border than it would inside of the border.

Q And what follows from that?

A It would mean that if industries were established on that gas in Montana, they would have the - they could then compete on the tariff-free market in the United States, whereas the industry on the Canadian side would have to take the hurdle of, I would say, at the present, an impossible tariff situation.

.....

CROSS-EXAMINATION BY MR. S. B. SMITH:

Q Mr. Donald, am I correct in interpreting your evidence to mean, broadly speaking, that you think that there is a great future in Alberta for the development of the petrochemical industry based upon the production of oil and gas?

A That is right.

Q The contribution of fuel towards the manufacture is, in one sense, minor, isn't it? The cost of fuel in the ordinary manufactured product is not a great problem, and is not a great proportion of the cost ordinarily of the article?

A There again you cannot generalize. It is a high item in cement, and it is a very high item in the cost of ammonia,

in the case of the ammonia plant, and I think in the cost of the cement, two-thirds of the cost is fuel.

Q I mentioned the other day a quotation by Mr.Zinder in his submission to the Dinning Royal Commission to the effect that during recent years fuel has contributed 1.5% of the total value of the product ordinarily, which is low, isn't it?

A Well, I do not think that is what we were talking about. I suppose that he is taking industry as a whole in making that statement, is he not?

Q Yes, I think so.

A Obviously.

Q I am speaking at the moment of industry as a whole?

A All right.

Q And not of the petrochemical industry or the other industries that we have been talking about?

A All right.

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Q Now you talk about the production of sulphur and of butane and propane. Can you tell me to what extent butane and propane are the base for the petrochemical industry?

A Well, they form, as a source of ethylene, they cover a wide range of products in the petrochemical industry.

Q And are the primary base for the petrochemical industry?

A The primary base? They are an important base, yes.

Q A very important base?

A Yes, a very important base.

Q And you do not get sulphur produced and butane and propane in Alberta, of course, unless you produce gas?

A Yes, usually a by-product of oil production.

Q Yes, oil production and gas production?

A Well, not necessarily.

Q Well, gas and oil together?

A Yes, that is right.

Q Now you spoke to my friend Mr. Fenerty of gas being heat units and if you export natural gas that is in pipe lines, do you export the sulphur in the natural gas?

A Do you export the sulphur?

Q Yes?

A No, it is usually scrubbed.

Q Yes, and the sulphur is retained here then, is it not, when you export natural gas and do you usually export propane and butane in natural gas or would you extract them here?

A Well, sometimes it is in the pipe line.

Q Do you know of any cases in which it is distributed in a pipe line?

A Yes, they are presently building a project in Tennessee, a joint operation between the Tennessee Gas and Transmission Company and the Matheson Chemical Company, and they are putting the propane and butane into the gas and scrubbing it out again at that point.

Q At the delivery poiht?

A Yes.

Q But that is the exception rather than the rule?

A It is a new development.

Q It is the exception. Ordinarily, butane and propane are taken out before the natural gas is transported, is that not right?

A Yes.

Q And then the natural gas is transported and is used for fuel purposes, and, with the exception you mention, not as a raw material at the delivery point. That is correct, is it not?

A Well, it depends on the distance that the gas is transported.

Q I am speaking generally. When you transport natural gas in these vast pipe lines in the United States, and the natural gas gets to its destination, it is used as fuel and not as a raw material?

A No, that is not altogether true. There are a number of ammonia plants in the United States that are a considerable distance from the point of production of the gas that are operating as ammonia plants.

Q But my statement is substantially correct, is it not?

A Yes, I think so.

Q Mr. Donald, you would agree, I have no doubt, that the discovery of oil in Alberta, in Turner Valley, Leduc, Redwater and other fields, has contributed substantially to the development and prosperity of the Province of Alberta. That is very obvious, is it not?

A I think so, yes.

Q We have as a result of the oil industry capital expenditures in exploration, drilling, development, in refineries, the construction of refineries and the construction of pipe lines, and we have revenue to the Provincial Government through the sale of land and royalties and these things have advanced the prosperity of Alberta very substantially?

A I think so.

Q And the development and use of gas and the consequent development of the petrochemical industry here will equally- perhaps not equally - but will also make a very important contribution to the advancement and prosperity of Alberta?

A Yes.

Q It is perhaps impossible to divide the gas and oil but there are many differences and I do not suppose you could measure them comparatively in their respective contributions in the future towards the prosperity of Alberta and its development, but would you agree that gas will contribute very greatly, likely?

A Yes.

Q It might be comparable to the degree of prosperity which oil has contributed to Alberta?

A Well, now, I do not know.

Q I say it might be?

A Well, yes. "Might" is a very wide word.

Q It is impossible to forecast?

A Yes.

Q But gas will undoubtedly assist in the development of Alberta and the building of its prosperity, increase in its population and in its consequent wealth very materially, is that not so?

A I think it is a very important natural asset, yes.

Q And that the petrochemical industry is altogether likely to be right here in Alberta, in your view?

A I think so, yes.

Q That is where it has got to be, according to your idea?

A In Canada, yes.

Q And Alberta is the logical place for it?

A Yes.

Q Now, if we are going to produce all these chemicals, and going to get this advance in development of Alberta as a result of having natural gas, then we have to develop our natural gas resources, haven't we? We cannot have these petrochemical industries and the various things that you have talked about without supplies of gas in large quantities?

A That is right.

Q And in order to get a supply of gas in large quantities we have to have a stimulus to provide development, exploration, the finding of gas and its production, haven't we?

A I would presume so. But I have always been of the understanding that most of the gas developed here is a by-product of oil.

Q I quite agree so far it has been. I quite agree. I just want to read to you what Dr. Hume stated, Mr. Donald. Could I read a short statement of his to you:

> "The experience of the past where large gas supplies have been found in drilling for oil, will, it is confidently expected, be repeated in the near future. Particularly ought this to be so now that the exploration companies are much more conscious than formerly of the possible early value of gas and will undoubtedly test zones that were at one time disregarded because they gave no evidence of containing oil."

Then he goes on:

> "If to this presently large projected programme of drilling in search of oil should be added the incentive of a price for gas which will justify exploration for this alone, with the assurance that a market will be available when sufficient quantities are developed to warrant the market, there would seem to be every expectation that further enormous supplies of gas would be found within a reasonable time."

Would you have any quarrel with that statement? In other words, the development of a market for gas at a suitable price would undoubtedly stimulate in Alberta a search for and production of natural gas?

A I think that is so, yes.

Q If we get an intensive search for gas alone and greatly

increased production of gas in Alberta, that likely will lead, in your view, I take it, to the advancement of the prosperity of Alberta and the increase of the petrochemical industry in Alberta?

A It will make - any further advance makes the position more attractive.

MR. NOLAN: Mr. Chairman, so far as the development of the chemical industry in Alberta is concerned, I think I should tell the Board that we intend to cover that in the evidence that we will adduce and we feel that no good purpose would be served by discussing it with Mr. Donald at this time.

MR. McDONALD: Mr. Chairman, I think that this particular question is of some importance to the producer of gas, particularly. After all, he is the man that has invested his money in finding gas and I think he is the one who should have the most information in regard to what is to be done with it. I would respectfully suggest, on previous occasions we have heard Mr. Donald and he has not furnished us with any written submission on which we could form a cross-examination. I am not prepared to examine Mr. Donald today and I would like to reserve my right to cross-examine him tomorrow morning.

THE CHAIRMAN: Mr. Steer, will Mr. Donald be available tomorrow?

THE WITNESS: I can be, if necessary.

THE CHAIRMAN: Then if you will be here tomorrow morning we will appreciate it.

EXAMINATION BY DR. GOVIER:

Q Perhaps I might ask you two or three questions now. I take it you are familiar with the conservation plant which is operating in the Leduc field, are you?

A Not too familiar, no. I know something about it.

Q Do you know that that plant has from the natural gas a stream of propane and a stream of butane?

A Yes.

Q Do you know that to date at any rate it has not been possible to find a market for all of either of those fuels?

A Yes.

Q In the light of that, Mr. Donald, and also in the light of the fact that gas,if produced from the Jumping Pound field, will also result in the by-production of a considerable amount of propane and butane and gas, if produced from the Pincher Creek field, will also result in the by-production of a considerable amount of butane and propane, do you believe that the export of residue gas outside the Province would significantly prejudice the development of the petro-chemical industry in this Province?

A Well, I think perhaps my views in this export of gas matter are influenced to some degree by the fact I am a Canadian. I take very little exception, if any, to the export of gas in any form within Canada. If it is exported within Canada and used within Canada, it will aid the Canadian economy. I do, however, feel that if this gas is moved across the border to the South and sold at low prices, the income of the Canadian economy will be slight

as compared with if it were used in this country.

Q Let us for the moment confine our attention to the possible development of the petrochemical industry in Alberta, and referring back to my original question, do you believe that the export of residue gas outside of this Province will significantly influence the development of the petrochemical industry inside this Province?

A Is it not a question of the quantities you have left? In the petrochemical industry they will probably require propane and butane as the raw materials and in addition have large heat requirements, but providing the large heat requirements can be taken care of by the excess propane and butane, your demand for natural gas would be lesser or greater. But if you take these oxygenated compounds with which you are familiar, such as the operations that are being carried on by Celanese in Texas and by another company there, they use large quantities of heat, of natural gas for heating, in addition to the propane and butane fractions. In other words, I do not think the export of gas outside the Province would prohibit the petrochemical industry at all, providing that there is a sufficient quantity remaining to give low cost heating units.

Q Then, Mr. Donald, would it follow that you believe we should make sure there is sufficient to meet the gas needs of the Province, to supply the heat requirements of any industry, but that the raw material requirements of the petrochemical industry, propane and butane, would in no way be prejudiced by export. Is that your opinion?

A I think this, that propane and butane, ethane, and any ethylene that is there will constitute the main raw material for the petrochemical industry.

Q Yes?

A If you take the extension of your ammonia programme and your other commercial programmes, you will be forced back to natural gas.

Q I am trying to get a crystallized opinion. I recognize you have done a great deal of thinking on this whole problem. I wish we could get the thing crystallized some way or another?

A I think I know what you are getting at, Dr. Govier. If the reserves of gas are so large that all the Alberta requirements in the foreseeable future can be taken care of and there is then a surplus, I do not believe it would have any effect on the extension of the chemical industry in Alberta, except insofar as if, for example, a chemical plant were established outside the borders of Alberta which might be established in Alberta, that would be the only point we would have any difficulty on. But the total requirement - I think perhaps this covers the point - the total requirements of the chemical industries are a relatively small proportion of the total industrial requirements at any time and they will not significantly, I think, affect the total demand.

Q I was going to ask you a question along that line in just a moment. But getting back to this basic question about export and its possible effect on the petrochemical industry

as such, the Board has heard evidence to the effect that without export it might not be economical to recover, or I should go even further, without export there might not be any production of wet natural gas and there might not be any propane and butane available and therefore there could not be a petrochemical industry. What is your view on that proposition?

A Well, I think, I am not too familiar with the petroleum industry but my understanding is there will be a great deal of propane and butane produced in the drilling for crude oil. Now whether or not that is going to be enough for the requirement or not I do not know. If more still is made available, it will mean presumably that it will be obtainable at a lower price which will make it more attractive to the chemical industry. One essential requirement of the chemical industry is low cost butane and propane.

Q Mr. Donald, suppose there were a total of 600 barrels a day of low cost propane and butane available today and there was no market for it, do you believe that in the next 4 or 5 years it is likely that the petrochemical industry could develop to consume that volume of propane and butane?

(Go to page 320.)

A Well, currently there are, as I told you, some several interests in the chemical industry who are looking at that situation and the criticism has been that that is not a large enough quantity for some of the things they are thinking about. Now, I think for other things that can be done here, take ethylglycol production, things of that sort, it is more than sufficient for the domestic demand, but for some of those plants these people are talking about where they are thinking of large production with export to the East and one thing and another, the requirements do not appear sufficiently large, the quantities do not appear sufficiently large.

Q DR. GOVIER: So you think for some kinds of development at any rate we should have a greater production of propane and butane?

A It would tend to stimulate the production.

Q If there were no export it might start earlier?

A Quite possibly.

Q Mr. Donald, you gave some figures on the development of the petrochemical industry in the United States. I wonder if you have available any figure indicating the annual consumption of gas by the petrochemical industry in the United States?

A I have had the figure. I have not got it with me. I will see if I can hunt it up before tomorrow.

Q I was just wondering if we might apply to that figure some population ratio, 1 to 10, to get some indication of what we might be looking forward to here.

A I will see if I can hunt that up before tomorrow.

Q The question of freight rates has been discussed at length in these proceedings, as you no doubt are aware. Many people have expressed the view that the freight picture is such here that production of petrochemicals in Alberta would not be economical in the light of the large freight increment to the market. I wonder if you can help us along that line by perhaps indicating your opinion in answer to these questions. Suppose a product, a chemical were produced here from natural gas and was sold in the Eastern market for 10¢ a pound, and assuming a reasonable ratio between production cost and selling price, do you believe just as an opinion that it would be possible to ship that product in competition to the Ontario market?

A 10¢ a pound?

Q Yes. Then I was going to ask you if the product sold for 50¢ a pound. See if we can get some general idea.

A 10¢ a pound is $200.00 a ton. The freight rate in bulk for fertilizers and things of that sort from Alberta is around $30.00 to $35.00 a ton. I believe the differential in heat unit cost here would offset that in that price area. I think the articles that are going to compete are the ones where there is a large consumption of energy in their production. Ammonia is probably as good an example as any. Ammonia is being shipped from this plant here all over the world in competition with other plants all over the world, and freight is not a barrier to it.

Q You think something that sold for 10¢ in Toronto, provided it consumed a large amount of energy in its manufacture,

might be made here?

A Ammonia is not 10¢ a pound. $75.00 a ton in Pittsburgh was a recent price. That is about 3¢ a pound, a little over 3¢ a pound. There is another point of view about that, of course, that the U.S. Southwest production is not being consumed there, it is being consumed all over the United States.

Q It is mostly being moved by water?

A No, I do not think so. I think the things that are moved by water would be the fertilizers and things of that sort but where you get down to these other products I do not think a great many of them would economically be moved that way. Anyway, it would be only on the U.S. seaboard. Anywhere in the interior the cost of moving by water and train, shipping by rail east, would offset the direct rail charges. They have been moving, you know, very large quantities of some of these solvents by water from Southeast Texas into the Eastern seaboard. There are quite a number of those plants that are well inland.

CROSS-EXAMINATION BY MR. McDONALD:

Q If I might ask a question. As Dr. Govier has mentioned, did I understand you to say the ammonia from this plant is being sold in Ontario in competition to the Welland plant?

A I doubt if it is at present, Mr. McDonald. Just at present there is a world-wide shortage of ammonia.

Q My question is, is it being sold in Eastern Canada in competition to the Welland plant?

A I do not know.

Q Isn't there a large difference between - -

A I am quite sure that ammonia from this plant can compete with ammonia produced in Ontario from coke.

Q It is not being done?

A You will have to ask the people that market it.

Q What I had in mind is that the freight rate as between here and Ontario is one thing, and to sell ammonia in Australia or in China is another, there is a difference between the two.

A It has been the general feeling that if the ammonia position got into a long position where there was excess production the Ontario plant would not be able to face the competition from here, and I think that is correct. You see, coke is up to a pretty high price in the East and your natural gas prices are not changing substantially. The tendency is for ammonia to go up very rapidly in the case of the East plant.

Q MR. STEER: Did you say the Ontario ammonia going up?

A I do not think so, laid down in those areas there.

CROSS-EXAMINATION BY MR. S.B. SMITH:

Q Mr. Donald, you do know that there has been export of tremendous quantities of natural gas from Texas by pipe line?

A It is being shipped out of the State of Texas, yes.

Q And at the same time there has been a tremendous development in petrochemical industry in Texas?

A That is right.

Q And there was in Texas a 1 billion dollar capital expansion during the war period, was there not?

A Something of that order, yes.

Q And since the war there has been some 300 million additional capital expenditure invested in Texas?

A That is right.

Q In the petrochemical industry?

A Yes.

Q Am I correct in those figures?

A I think so, yes.

Q MR. STEER: Didn't you say 500 million?

A I was going to say the more recent figures indicate a larger figure than the 350, they would indicate 500.

Q MR. S.B. SMITH: I was giving you figures of your own here but perhaps they are not up to date.

A The most recent figures I have, the investment now to date plus what is being planned runs about half a billion.

Q MR. STEER: I wonder, Mr. Donald, how many of these industries that you are speaking of are dependent on propane and butane and how many of them are dependent on the gas stripped of those constituents. I understand that the ammonia business takes in the natural gas stripped of butane and propane.

A Yes.

Q Stripped?

A Yes.

Q And there is no waste of it in that industry. How many others are there of the same type?

J. R. Donald,
Cr. Ex. by Mr. S.B. Smith.
Dr. A. D. Brokaw,
Dir. Ex. by Mr. Nolan.

A Well, by far the greater majority of the products that can be produced by the petrochemical industry are produced from materials other than methane.

Q Yes.

THE CHAIRMAN: Mr. Donald, we will call you in the morning then.

MR. NOLAN: Mr. Chairman, I think I am next on the agenda and I am going to ask Dr. Brokaw to present his report. If the Board and counsel will look at a document entitled "Deliverability Study of certain Alberta Gas Fields by Albert D. Brokaw" that will be the document which we are about to submit. Perhaps you will give it a number.

DELIVERABILITY STUDY OF CERTAIN ALBERTA GAS FIELDS BY DR. BROKAW PUT IN AND MARKED EXHIBIT J-12.

ALBERT D. BROKAW, having been first duly sworn, examined by Mr. Nolan, testified as follows:

Q Dr. Brokaw, you are Albert D. Brokaw?

A I am.

Q And you have been sworn?

A I have.

Q What are your qualifications, Dr. Brokaw?

A As to education?

THE CHAIRMAN: The Board is quite prepared to accept his qualifications.

THE WITNESS: I beg your pardon?

THE CHAIRMAN: We do not need to have you qualified.

Dr. A. D. Brokaw,
Dir. Ex. by Mr. Nolan.

Q MR. NOLAN: Dr. Brokaw, you prepared a deliverability study of certain Alberta gas fields which has been marked as Exhibit J-12?

A I did.

Q Perhaps you would be good enough to read that to the Board insofar as you think it desirable to read, omitting those portions which you think are only of use to the Board for their study and perusal elsewhere. Perhaps the introduction should be read, should it, Dr. Brokaw?

A GENERAL NOTES ON DELIVERABILITY

INTRODUCTION

The somewhat loosely used term "deliverability" as applied to natural gas production, refers to the amount of gas that may safely be produced without materially damaging the well or field, except, of course, by the depletion of its reserves. The best estimates of deliverability are based on the judgment of a skillful operator who has had enough experience in the particular field to learn the limit of the rate of production beyond which the risk of damage to the wells is likely to appear.

Deliverability is conditioned to a large degree by reservoir conditions, such as porosity, permeability, thickness of productive formation, the presence or absence of water or oil, the proximity of the bottom of the well to the gas - liquid interface, the competence of the reservoir rock to withstand differential pressure at the well bottom to prevent sanding up and other similar features. The nature of the hydrocarbon content also enters into the problem, particularly in the case of

gas-condensate wells, where the rate of production may seriously affect the recovery of condensate. Further, an excessive pressure drop at the well head may cause sufficient chilling of the gas to induce the formation of ice or gas hydrates, with attending freezing of valves and clogging of gathering lines, especially in cold weather when the demand for gas is ordinarily at its peak.

In the case of a gas field as a whole, economic considerations are of vital importance. The maximum deliverability can be obtained by drilling the greatest possible number of wells, but the cost would ordinarily be prohibitive. On the other hand, if too few wells are drilled, the delay in recovery of initial cost may be too great, and the limit of deliverability from the field may be so small that the extension of pipe lines to the field would be impracticable.

In the case of a new or only partially developed field, many of the above factors are only partially known even under the best development practice, and forecasts of deliverability must, of necessity, be based on reasonable assumptions and such measurements as may be available. The fundamental bases for such assumptions should be judgment, based on experience in the natural gas industry.

Q Now, I observe, Dr. Brokaw, your next main heading is "Pressure Capacity Tests". Is it your intention to read that to the Board?

A I think not, unless it is desired. It is a brief outline of the history of the development of this method of control

of production and the derivations, and it is a method which is still being developed. There are still points to be done but it seems to afford about the best basis that we have where we do not have an experience of some years in operating the fields.

In this connection I have shown a diagram following page 4 which I have found convenient. Others may not find it so but this is a back-pressure, a chart showing back-pressure curves of various slopes but instead of being in terms of the individual well it is in terms of per cent of the absolute open flow capacity that will be delivered at various percentages and the difference between the formation pressure and sand pressure squared, or the formation pressure squared minus the sand pressure squared over the formation pressure squared, so that it is a percentage relationship. The figures on the right hand side of the chart show the percent of back pressure eliminating the square because I have always found it a little difficult to visualize rapidly from a logarithmic chart. I thought that perhaps some other people also have such difficulties. Now, those figures show, for instance, that at 80% back-pressure we would have a delivery, if the slope of N is 70 of, let us say, 43% of the open flow capacity. If the angle of slope is 85 the delivery would be approximately 36% of the open flow capacity. I read that wrongly, I am sorry, I was reading from the line opposite 80. It would be 80% of the open flow capacity if the slope is .7. It would be about 41% if the slope is .85,

and it would be 35% if the slope is .80. The usefulness of this to me is in developing pressure capacity curves, also in the fact that it is applicable to any well which is of the characteristics shown. It is very simple to construct it because you take any pressure factor that has been developed and simply start at the upper right hand corner of one of these two cycle logarithmic charts and draw a line from that point parallel to the slope of the curve which we are converting from a specific well curve into a general curve of percentage character.

Following that is some discussion of derivatives and the justification of it more or less mathematically. Following page 7 I have placed a chart showing pressure capacity curves and this is the original form which was developed in 1925 or some such time by, I have forgotten the name. Anyway, this was the form which was first developed by the Bureau of Mines and appeared about 1927 or 1928 in Deal's Handbook on the Natural Gas Industry, which at that time was one of the bibles that we used to use. It shows two curves, one for the slope value of the back-pressure curve, N equals 1, and the other for the slope of the back-pressure curve N equals .7. These are not drawn precisely accurately, but I did not think the errors were sufficient, since this was simply introduced as a sample, to change the curve. For instance, this shows that in terms of percent of open flow capacity and the percent of back pressure, if you choose that at 90%, the back-pressure if the slope is equal to 1, we would have a

production of about 18% of the open flow capacity. However, if the slope is .7 we would have a production of about 90% - - I should say, of about 30% of the capacity, just going horizontally from the 90% line through the two curves. We used this method as early as 1927 without any back-pressure tests or anything of that sort. We used this in the Whitepound in Texas where there was a great deal of difficulty with water. That was in the days when we used to go out and open wells and blow them to the sky until they had settled down to where we thought was reasonable stabilization and then gauged them with peto tubes. Where we could not do it on those wells because they were full of water, not full of water, where they were open with considerable water and sand entrained in the water, and gas came out, and still for our reports at that time there was a fetish that almost required open flow capacity, so we made such tests and projected the curves not on any mathematical basis but more or less by inspiration, I suppose. Our engineer Fulhart published one of the first articles on practical applications in the field in 1927, if I am not mistaken.

The next chart is simply a derivative chart from the .85 back-pressure chart on the first of the charts and it shows the decline of initial potential in terms of the decline in the per cent of formation pressure. This, again, is a percentage curve and would apply to any well having the characteristic slope N equals .85.

Q Well, that brings you to the next main heading, does it?

Dr. A. D. Brokaw,
Dir. Ex. by Mr. Nolan.

A That is correct.

Q The "Limit of Allowable Production". You would like to read certain paragraphs from that and perhaps you would indicate to the Board what you are proposing to read.

A Page 8.

LIMIT OF ALLOWABLE PRODUCTION

The limit of allowable production for gas wells imposed by regulatory bodies is commonly some percentage of open flow capacity or potential, but it is probable that damage to the wells is largely the result of the difference between formation pressure and pressure at the sand face.

The danger of coning bottom water and tonguing edge water is a function of permeability and differential pressure at the bottom of the well. The latter is also a major factor in sanding up or sand entrainment in the gas stream and contributes to the tendency toward condensation of water and heavier hydrocarbons at the bottom of the well. In cases of extreme pressure drop hydrate formation may seal off the sand face and seriously restrict production.

I only know of one case where that was the interpretation of a serious drop in the production of gas in Mishquim County, Ohio. There was a rather high pressure gas pool reservoir, thin, very high permeability, and the wells would have large flow. We opened them up and they would blow, seemed to stabilize and then drop in pressure and would have to be shut in for a period before they came back to what

they were before. The interpretation of that at that time was that the gas had some moisture in it and the interpretation was that it was due to ice forming on the sand face. At that time we had not yet discovered the hydrates of methane and the other hydrocarbons, so it might be hydrate production. The following paragraph is simply a comment and a slight change in the form but not in the actual equation.

Where the limit is imposed on the basis of a per cent of open flow capacity, the withdrawal per well decreases as the open flow capacity declines through depletion, and may necessitate more additional drilling than would be required if a fixed differential between formation pressure and pressure at the sand face were the basis of allowable production.

Assume, for simplicity, a well with an absolute open flow capacity of 20,000 Mcf/day, a formation pressure of 2,000 p.s.i.a., and n = 1, with an allowable production of 25 per cent or 5,000 Mcf/day. This would involve a back pressure of 1,720 p.s.i.a. at the sand face, or a differential pressure of 280 p.s.i. When depletion had reduced the formation pressure to 1,000 p.s.i.a., the open flow capacity would have declined to 10,000 Mcf/day, the allowable to 2,500 Mcf/day and the differential pressure to 140 p.s.i. If the same well were produced at a constant differential of 280 p.s.i. the production at the start would be the same, but when the formation pressure had been reduced to 1,000 p.s.i.a.,

the well could still produce about 4,500 Mcf/day. In order to deliver this amount under the 25 per cent of open flow capacity allowable, another well completion would be required.

(Go to page 334)

Except where cycling is practised, limitation of production of gas condensate wells has commonly been based on the available economic outlet for gas rather than on a fixed per cent of the open flow capacity or potential.

A further restriction on deliverability in the form of limitation of area per well is often imposed by regulatory bodies. Unless this is based on the specific reservoir characteristics it may result in inefficient operation if a reservoir has low permeability, as deliveries may decline to or below the economic limit while areas between the wells might well be drilled and more gas thus be recovered from the field. It may be noted in passing that during the war the limitation imposed on well spacing was fundamentally a matter of conservation of steel rather than gas, and that when the deliverability of gas became an acute problem the limitation was abated in some producing fields to increase deliveries. In many of the fields developed before steel allocation was instituted, it was common practice to develop on a spacing of one well to 160 acres or even less, but when the steel supply was restricted there was an effort to limit development to one well for 640 acres, often forcing unitization of a number of tracts.

I might interpolate there. We had to get an allocation of steel to drill a well, and we could not get it unless this unitization was accomplished.

While this may be efficient in

fields of high permeability, it is reasonably sure that in relatively shallow fields of low permeability both conservation and economics will be served by closer well spacing. Except in special cases it appears that for the best results well spacing should be determined by economic considerations.

Certain other aspects of deliverability are worthy of mention. Thus, the deliverability of gas from an oil field depends almost entirely on the gas/oil ratio and the rate of oil production, which, in most cases, is controlled by regulatory authorities. It may safely be assumed that production of gas from gas caps will be limited with a view to efficient oil production, but production of solution gas is unavoidable, and its conservation and use are of real importance.

Then skipping to page 11.
The problem with which we are here concerned has to do with the deliverability of the gas fields of Alberta, and the first consideration for such a study is the recoverable reserves of the fields.

On our behalf Mr. S. W.Slipper has presented an able report on the gas reserves of Alberta, which was chiefly concerned with the present and future gas reserves of the Province as a whole. We are in essential agreement with his estimates and conclusions, and consider his report a valuable addition to the already large number of excellent reports available to the Alberta Petroleum and Natural Gas Conservation Board, as it presents a refreshing approach through broad geologic and stratigraphic conditions to the

consideration of the broader aspects of the subject, without minute attention to the individual fields.

We have made other studies of the gas reserves which were presented to the Dinning Commission, and these reports with others presented to the Commission, along with other reports that have been submitted to this Board, afford a mine of technical information and opinion which is probably unparallelled and is to a large extent in general agreement.

In addition to these, the recent report on, "Natural Gas Reserves of the Prairie Provinces", by Dr. G.S. Hume and A. Ignatieff, dated July 1, 1950, an official publication of the Department of Mines and Technical Surveys of Canada, has been made available. We consider this the most comprehensive and authoritative report covering all of the fields without any possible taint of bias, and in general we shall use their estimates for studies of deliverability, except for possible cases where later development or new well tests indicate the necessity of material changes.

In cases where deliverability estimates with which we are essentially in agreement have been submitted to this Board, we do not expect to submit parallel estimates, believing that the introduction of minor differences will tend to confuse rather than clarify the picture and will add unnecessarily to the already voluminous record.

If we are correctly informed, the Alberta Petroleum and Natural Gas Conservation Board has not issued any formal regulation limiting withdrawals

of gas to a definite percentage of well capacity nor stipulating minimum spacing of wells, but there appears to have been a general understanding that the limit of allowable production is 25 per cent of open flow capacity, and that no more than one gas well should be drilled on a section. In the following discussion of deliverabilities we have, in general, adhered to these conditions, except for cases which will be designated.

The formulation of deliverability forecasts, even where the fundamental data of reserves, area, pressure and flow characteristics are well established, is subject to considerable variation, especially in the matter of rate of drilling additional wells and the desired rate of withdrawal from the field. As a consequence, two or more forecasts, based on the same fundamental data, may give very different results when projected over a long period of years.

It is not at all likely that the suggested details of development and production will be carried out as indicated in the schedules, as they are limited to presently known and proven fields. As soon as the spur afforded by adequate market for gas is felt, development and extension of known productive areas and the discovery and development of new fields is sure to follow, and within a very few years those forecasts will have become obsolete.

MR.NOLAN: I wonder, sir, if that may - be a convenient point to break off, because there is an absolute division there.

THE CHAIRMAN: Yes, we will have a short

recess.

(Hearing resumed after short adjournment).

Q MR.NOLAN: Dr. Brokaw, I think at adjournment time we were at the main heading "Deliverability Studies" in the middle of the page, in the middle of page 13. Will you please go on from there?

A Yes.

DELIVERABILITY STUDIES

The following studies and schedules are limited to estimates of deliverability of various gas fields, assuming for each a program of deliveries and well completions. Geological conditions have been discussed in an earlier submission, and, as stated earlier, we had adopted the reserves indicated in the report of Hume and Ignatieff as a basis for our forecasts. None of the schedules is carried below what we believe to be a reasonable anticipated abandonment pressure.

Q Now, your first field is Jumping Pound. How do you propose to deal with that, Dr. Brokaw?

A Starting in the second paragraph, I will read from there.

The wells are being prepared for new tests which will pretty surely yield more satisfactory results than those up to date, and the well now being drilled will take large cores in the limestone. When these data are available, a completely new estimate of reserves and forecast of deliverability may be necessary.

In the following tabulations of

deliverability, we have estimated the average potential at 35 MMCF and have computed the decline in open flow capacity on the basis of n = .85, pending the results of the contemplated tests, which have been delayed because of inability to get prompt delivery on some of the needed equipment. Shrinkage and plant fuel will probably require 15 per cent of the volume of raw gas, and available pipe line gas is estimated at 85 per cent of raw gas deliveries. Thirteen wells may be drilled with one mile spacing along the proven area, and development program is based on the completion of two new wells each year after 1950 until the total of thirteen has been completed. Because of the expense of moving rigs into and out of the field, it is probable that drilling will be carried on continuously to complete the development of the field.

Now, this is one case where the area is less than 640 acres to the well. The wells are spaced a mile apart, but the structure itself, being less than a mile wide, is such that we have placed more than one well to 640 acres.

Now, the table of deliverabilities.....

Q Following page 15?

A On the following page. The table of deliverabilities shows in the first column the year, then the raw gas reserves as taken from Hume and Ignatieff, the formation pressure per square inch absolute from the same source, the potential per well, as indicated on the previous page, the number of wells based on the drilling program speci-

fied. Then there is the total potential, which is simply a multiplication. The potential per well, I should have mentioned, that is based on a .85 back pressure slope. We do not know what the slope is. The measured slopes indicate that the - I believe Dr. Hetherington used a slope of 1.15, or something of that sort, which is pretty certainly in error, and this allocation of .85 as the slope value is in an arbitrary one.

The total potential then is the average potential, and the average potential is supposed to be declined along the .85 basis. The total potential is simply the average potential multiplied by the number of wells.

And then the peak day allowable is taken as 25% of the aggregate open flow capacity. Perhaps it would have been better to have said peak day available rather than allowable.

The next column is the daily average withdrawals projected into this program; then the daily average per well; the per cent of potential; and the annual withdrawal raw gas production. Then the net gas to pipe line in terms of the peak day, the available for peak day, the daily average, and the annual totals.

The total withdrawn, I mean, the total deliverability to the market in this period is estimated at 428,570 billion cubic feet. This is some 7% in excess of Mr. Davis's figure for the total amount available, and I consider this to be in essential agreement.

Q What was his figure, Dr. Brokaw?

A 400 billion, mine is 428,but as I recall it Mr. Davis did

not distribute it through the period of years as we have done here.

The note on the peak day allowable or available is to the effect that it is limited to 10% overload on net plant output or net peak day allowable production from the field. That is to say, it is a concession to the fact that the plant should operate as nearly as possible at a flat rate, but that it is possible in an emergency to run more than rated capacity.

Q DR. GOVIER: Dr. Brokaw, what have you taken as the plant capacity here, or have you taken any definite figure?

A That was done by one of my assistants, and I have forgotten what that figure is. I will supply that to you.

Q Thank you.

Q MR.NOLAN: The figure, Dr. Brokaw, is 50 gross?

A 50 million a day gross.

Q Yes?

A On page 16 with regard to Legal, Bon Accord, Picardville and Viking Equivalent.

While these three areas are separated by considerable distance they all appear to be of similar type and for convenience they are considered together for deliverability forecasts. As in the case of the Lower Cretaceous wells in this general area, the productive areas have not been delimited by drilling and each may develop into more extensive fields. Hume suggests the possibility that the area of production may extend to Bon Accord and Excelsior, where the Viking

equivalent has been found to contain considerable gas, giving a possible area of 250 square miles, but restricts the reserves to the Legal-Waybrook area and the Bon Accord area, with a total of 16 square miles. Slipper suggests a possible area of 120 square miles and possible reserves of 240 MMMCF. The Picardville area is pretty surely a separate reservoir.

Reserves in place, as estimated by Hume and Ignatieff, are as follows:-

Legal-Waybrook Area	15.3 MMMCF
Bon Accord	9.9 "
Picardville	17.7 "
Total	42.9 MMMCF

Deliverability forecasts have been based on total reserves of 42.9 MMMCF, average formation pressure of 830 p.s.i.a., average potential of 10 MMCF at initial formation pressure, declining with a back pressure slope of n = .85. Ninety per cent of the raw gas production is considered available for delivery to markets.

Now, in making these estimates of deliverability, since it was required or desired, at least, to fit it into a complete and composite picture, going over the, or taking the Province's requirements, the requirements of the Province as a whole, and the availability of gas, and the desired distribution, it has been necessary in this to shift the initial year of operation of the field so as to fit it into a sort of jigsaw puzzle, and it was necessary in order to have a coherent picture, as Mr. Davis very well said, "You

can have as many answers as you can make assumptions", but this is simply taking liberties with the development program, pushing it on to a point where it appears to be most desirable. It is not the only one that could be done to achieve the same results, but it is one of the methods by which these results are achieved. These figures will be fitted into figures on the solution gas in other fields, which will be presented by Mr.Dixon. I have not had any material experience with solution gas. Mr. Dixon has had a great deal of it, therefore, this report covers only the fields that have been mentioned here, and these will be integrated into a complete and summary report.

Next comes the Manyberries field on page 17.

MANYBERRIES FIELD

In the following tabulation deliverability from this field is based on daily deliveries of 5 MMCF to the pipe line, or 5.3 MMCF of reservoir gas. Since the date of Hume's report a new well has been completed in the Manyberries sand in Section 2, Township 5 North, Range 5, West, extending the field about 4 miles previously considered proven. That is in the Manyberries sand. In our opinion this had added at least 6 MMMCF to the reserves in place, and reserves for the area have been increased from 34 MMMCF to 40 MMMCF for deliverability estimates. The average initial potential per well at initial formation pressure is estimated at 24 MMCF. No back pressure tests have been made, and the decline in potential has been based on a

slope of n = .85. Average initial formation pressure is estimated at 895 p.s.i.a.

That is a weighted average formation pressure.

It may be noted that since this was written the owners of the Manyberries field have submitted an estimate of the reserves in place, which were substituted for my 40 billion, a figure of 117 billion, that is, for reserves in place.

The composition of the Table is exactly the same as the proceding one, and unless there is some desire, I shall not repeat it. The amount withdrawn, the amount, I mean, of pipe line gas withdrawn is 33 billion, 620 million under this program as compared to Dr. HaWthorn's figure of 27 billion, 255 million, which was made on the basis of 34 billion as reserves instead of, as in my case, 40 billion. Was that not correct, Dr. Hawthorn's figures?

Q Yes. Counsel was just asking me who you were making the comparison with, and I said Mr. Hawthorn. He had a figure of 27 billion 255 million?

A Yes.

Q Yes?

A Now we come to the Morinville Area.

MORINVILLE AREA - LOWER CRETACEOUS

In the following estimate of deliverability we have combined the Morinville with Pacific Calahoo and Bailey Long Island wells because of their general similarity and because the productive areas have not been delimited by drilling. The probability

of a gas field of considerable area was suggested in my testimony before the Dinning Commission before the Calahoo and Long Island wells were drilled.

While very much larger reserves have been ascribed to the area in testimony before this Board by competent geologists who are thoroughly familiar with the area, our forecast of deliverability has been limited to the estimates of Hume and Ignatieff, who state, "as already indicated this calculated reserve may be a minimum for this area. It is believed that development wells could prove gas reserves very much larger than the amount here indicated." Their estimates of reserves are as follows:

Morinville	204.5 MMMCF
Pacific Calahoo	20.0 "
Long Island	9.6 "

The total reserves for the three areas are 234.1 MMMCF, the average formation pressure is estimated at 1,100 p.s.i.a., the average potential at initial formation pressure is estimated at 15,000 MCF and the decline in potential is computed on the basis of a back pressure slope of n = .85. Ninety per cent of the raw gas is considered available for pipe line delivery.

And this again is deferred to initial opening in 1966, which is another of those arbitrary shifts which we have made. The area does not, I mean the amount available does not, of course, agree with either the Westcoast or McColl estimate because of the fact that we have accepted Dr. Hume's estimates of

reserves. We had no desire to depreciate the estimates of reserves made by Dr. Nauss or by Dr. Beach.

On page 19 the next field, I always stumbled, I always did stumble over the pronunciation of this until Hugh Beach told me that the drillers called it"Pendant O'Reilly", and that has simplified the matter for me very materially.

PENDANT D'OREILLE FIELD

In forecasting deliverability for this area we have used reserves of 290 MMMCF for the Pendant d'Oreille field proper, omitting the reserves of 18.8 MMMCF estimated for the California Standard area and 2.3 MMMCF for the Smith Coulee Field. Reserves of the Smith Coulee field have been materially increased by the completion of a new well 3 miles north and 3 miles west of the well for which reserves were set up, more than doubling the productive area, and additional drilling is definitely planned. Pressure in these two areas is somewhat below those of the major Pendant d'Oreille field, but the wells will surely be connected to one of the available pipe lines and may possibly be used to build up storage in the Foremost and Bow Island fields.

Deliverability estimates for the Pendant d'Oreille field are based on an average formation pressure of 748 p.s.i.a. and average potential of wells at initial formation pressure of 16 MMCF. No back pressure tests have been made, and a back pressure slope of n = .85 has been assumed. Initial delivery of gas is scheduled for 1954.

I was in Calgary during some of the early development of the Pendant d'Oreille field, and at that time I had the feeling that there might possibly be a water drive. I am sorry that Dr. Beach is not here. I meant to inquire on that. It may be, of course, that if there is a water drive - there is known to be water, a gas/water interface in the main sand, and if there is a water drive the potentials and deliverability would be sustained at a higher figure than they have been shown in this table.

(Go to page 348).

The table is the same in its organization as the others. The resultant deliveries to the pipe line are placed at 192,750,000,000 cubic feet as compared to Dr. Hawthorn's 194,519,000,000 cubic feet. The formation pressure at the close of 1981 is estimated at 224 pounds. I suppose I will hardly be able to check that when the time comes.

The only reason for not accepting Dr. Hawthorn's schedule in toto was the matter of distribution to years, and our methods and our figures are in extremely close agreement.

In the discussion of the Princess area, we have gone to somewhat greater and more elaborate discussions than in the others, in order that the Board may have the material that I think is significant available. It is a field in which there are a good many puzzles, an area in which there are a good many puzzles. For that reason, and because I was in Calgary during one of the stages or two stages of the development of the field and gave some attention to it, I have gone to greater lengths than I would ordinarily. I think, however, it might be just as well at the present time to skip to page 20 and the beginning of the fourth paragraph.

Q MR. NOLAN: Page 23, is it not?

A Page 23, I am sorry. Thank you. Beginning at the fourth paragraph:

" Recent completions of Lower Cretaceous gas wells near Cessford along the trend towards Hanna,

"Castor and Stettler where Lower Cretaceous wells have shown considerable promise, indicate excellent prospects of developing substantial reserves to the north of the Princess area (that probably should read 'north and west') particularly because the active search for Devonian oil production along this general trend will permit testing this horizon."

The paper yesterday evening reported the successful completion of a third Lower Cretaceous well in the Cessford area by the Canadian Delhi.

"While some oil has been recovered from the detrital zone" - I have inserted there 'below the Sunburst' - "the oil column is thin and there has been so much difficulty in shutting off gas that it is unlikely that the oil production is as important as the gas supply; and it is likely that the few wells which have shown oil will produce more oil in traps when producing gas than can be recovered by operating the wells as oil wells with a high gas and oil ratio.

Forecasts of deliverability have been computed on the following bases:

Reserves	241.2	MMMcf
Potential of present wells	70,000	Mcf
Estimated average potential of new wells (the present wells are shut in)	10,000	Mcf
Formation pressure	1,545	p.s.i.a.
Additional locations	10	
Composite back pressure curve	n = .685	

That is based on four back pressure tests that were made by California Standard on two wells, the last test being made in June or July, as I remember it, of this year, at our request. The steepest of the curves was almost exactly 30 degrees. The other three were 35, 35½ and 36, as I recall, and the average was almost, or I mean the composite was almost 34½ degrees and that is what we used.

"Further it may be pointed out that there is a suggestion of a water drive on the reservoir, which would serve to sustain pressure and well potentials, and may possibly reduce the number of wells required."

The evidence for the water drive was encountered in the well, I believe, drilled by Anglo-Canadian, which Mr. Webb told me of. It is on the record I think. Mr. Webb told me they had an Artesian flow of water from the sands, off the structure, below the gas horizon. That is the only information I have on it. The suggestion is there and it is perhaps not confirmable. The deliverability as indicated in the next table is the same sort of table. The total amount available for use under this programme to the end of 1981 is 149,150,000,000 cubic feet and the pressure at the close of that period, the formation pressure, is estimated at 539 per square inch absolute. In the discussion yesterday of the same field - perhaps not in the discussion but in the submission of the McColl-Frontenac group, the figure of production was, or the estimated recovery that they estimated was 168,300,000,000 cubic feet against our figure of 149,150,000,000.

Q THE CHAIRMAN: Mr. Brokaw, I wonder if you

would mind telling me where this reserve figure of 241 million is taken from?

A That is from Dr. Hume's report.

Q I may be wrong, but I have a figure here of 196. That is the Lower Cretaceous Sunburst and that corresponds, I think, to the figure that was quoted by yourselves in your original submission, in Dr. Slipper's, I think it was. I think the estimate was 196 in place and I think your figure showed 187 to 100 pounds abandonment pressure. Maybe I have got the wrong figures. But I would like to know where you got them?

A Oh, it includes the Patricia area of 45.1 billion.

Q Oh, I see. That is all in the Lower Cretaceous?

A It is all treated in a single block.

Q MR. GOODALL: Is that all Lower Cretaceous?

A Yes.

Q And takes in the top of the Madison also, does it?

A No, not according to Dr. Hume. It takes in perhaps some detritus. I think the reservoir there is a very difficult one.In most of the area, not in all, but in most of the area there is detritus, and this is intended to be the Sunburst sand above the detritus zone. I think there may be others. I am pretty sure there are places where the detritus is not separated from the Basal Lower Cretaceous sand by clay or shale septum and in those cases I think it is where we get the oil in the Sunburst sands. I am not quite sure of that. Then there may also be places where the reservoir includes part of the top of the Madison, although that is a little bit hard to grasp from

the standpoint of the geological history, as I understand it, because if there were an open part of the Madison, an open porous part of the Madison there covered by clay, well I suppose it might have migrated up from the Devonian at a later time, Mr. Goodall.

Q This did not include any Basal Colorados?

A No, not in this one. I have taken that in the next section. Does that answer your question, Mr. McKinnon?

THE CHAIRMAN: Yes.

A Dr. Hume's estimate for the Patricia area, does that satisfy your question?

Q Yes.

A On page 25 then.

" BASAL ALBERTA (COLORADO) SAND

Dr. Hume's estimate of reserves in the Basal Alberta is limited to the Denhart structure lying to the east of the Princess oil pool. The sand has also been found to contain gas in some of the wells in the South Princess field, and while no reserves have been set up they may contribute some gas supply when the deeper oil production has reached the economic limit.

In the area for which reserves have been estimated Anglo Canadian Rainy Hills No. 1, drilled in 1939, is reported to have shown 5,000 to 7,000 Mcf in a production test. No details of the test are available, except that the closed pressure rose to 1,050 p.s.i.a. in twenty-two minutes.

" More information is available on tests of the same company's Steveville No. 1, some 13 miles to the northwest. This well at first produced 6,460 Mcf/day with 570 gallons of water and 92 gallons of condensate. At that time the well was open to the limestone. After cementing off the limestone the well gave 4,700 Mcf with 221 gallons of water and seven gallons of condensate, against 800 p.s.i.g. on the tubing; casing pressure was 950 p.s.i.g. Closed-in pressure after two hours was 1,150 p.s.i.g. In a subsequent test the open flow capacity was reported at 12,000 Mcf after two hours wide open.

Princess Steveville Syndicate No. 1 showed 8,000-10,000 Mcf in a drillstem test.

Anglo Canadian Steveville No. 2 showed 1,480 to 1,650 Mcf with some water in a drillstem test. No other details are available."

Anglo Canadian Steveville No. 2 found a large flow of gas in the Lower Cretaceous but it went rapidly to salt water, again indicating the possibility of a water drive.

" It was generally believed that the Basal Colorado sand was not an oil sand and few, if any, adequate tests have been made in the score or more of wells that have penetrated this horizon in the general region.

Forecasts of deliverability have been made on the following bases:

Average open flow of wells	10,000 Mcf
Formation pressure	1,244 p.s.i.a.

Ultimate number of wells	30
Back pressure curve	n = .85
Reserves in place	99.0 MMMcf."

The deliverability schedule, as noted before I mean, is exactly in conformity in its structure to those submitted heretofore. The amount of gas forecast for withdrawal and use of a pipe line is $1,360,000,000 and compares with $8,400,000,000, as submitted by the McColl-Frontenac.

Now the Viking-Kinsella Field.

" VIKING-KINSELLA FIELD

Deliverability for this area has been estimated on the basis of the lower of Hume's estimates, namely, 1,116 MMMcf reduced to 1,068 MMMcf for estimated production since the autumn of 1947. Average potential of wells is estimated at 10.5 MMcf at an average formation pressure estimated at 706 p.s.i.a. Decline in potential is calculated from a back pressure slope of .85. Shrinkage of raw gas is estimated at 5 per cent. The development program is designed to provide 'as far as possible'"- that is interjected there - "for anticipated requirements and peak loads of the Edmonton system."

Except being supplemented by some solution gas from the Leduc area. Or some gas from the Leduc area, I am not sure whether it is solution gas or not.

"Again, it may be stated that there is scant probability that this amount of development will be necessary because of the large potential gas area

"to the north of Edmonton which is sure to be developed when and if an adequate outlet for gas is available. There are also prospects for development in the vicinity of the Texaco-Superior Ranfurly well, west of Birch Lake and the Jarrow No. 1 south of Jarrow, both of which lie outside of the field."

Now in this the table is the same as before. The estimated recovery from the field is 656 billions, starting in 1951, compared with Mr. Davis' figure of 612 billion.

Q MR. C. E. SMITH: What was that last total of your own?

A It is not in there, it should be entered, should it not? 656,460,000,000 cubic feet. The program as outlined has a very large number of well completions. I have approached that from, I have made a sketch really of an approach to that somewhat different from the one which was made yesterday. Here again it is a matter of assuming a good many features. Assumimg the cost of the well is $40,000.

Q MR. NOLAN: That is with the connection?

A Including the connection and a 20 year operation and an average of 3 million cubic feet per acre marketable. The items to be recovered under this programme, which is assumed to be a programme of an operating utility company which is entitled to earn 7% on its rate base, and an assumption also that this expense or this cost is entered into the rate base and stays at a net. Assuming further

that depreciation will - that the well will be written off over 20 years, then the average investment over the 20-year period is $20,000 and the interest or earnings, permissible earnings, on the assumption which I have made for 20 years on an average of $20,000 is 7% of $400,000, or $28,000. The depreciation, of course, would amount to $40,000 in that period. Maintenance and operation for 20 years, I have just put in a rough figure of $250. per year per well, or $5,000. Income tax, $28,000, as I understand it, would be permitted after payment of Federal and Provincial income taxes. The Federal tax would be, of 38%, would be $18,700 and the Provincial tax would be, as I think it is, would be $2400, making a total recoverable from that operation of $49,100 in order to get a $28,000 net required. Now, if we take the average section the total including the cost of the well and operating adds up to $94,100, and if we take the average section at 3 million cubic feet per acre, 1,920 million cubic feet, the total to be recovered 94,100, gives an average of 4.9 cents per thousand cubic feet before royalty. Now royalty is 1/8, so 4.9 cents is 7/8 of the actual outlay for gas and adding back that royalty gives us an average of 5.6 per thousand cubic feet for gas developed on a 640 acre location on the bases that have been set forth. That is probably more than is being paid for the gas now. It is not as much as will be paid. I mean if the other gas purchased outside of the ownership of the property, I am quite sure and it is perfectly clear to me that as a source of protection for deliver-

ability and for the peak load particularly, that it is not an unwarrantable programme of development. But may I repeat again the statement that I have no expectation that this programme of drilling 300 odd wells, 370 wells, will have to be carried out because of the anticipated development which I feel certain will come in the very early future or as soon as there is the spur of an available market for gas.

Now turning to Other Areas.

Q MR. NOLAN: On page 28?

A On page 28. There is nothing very special about these figures. They are submitted to the Board. I do not know as there is any particular point in my reading them. The production or requirement in most areas has risen. In Lloydminster it dropped in 1949. But most of these have to do with areas which are self-contained or if not adequately supplied are too far away for the size to be attractive for service by pipe line companies.

Q MR. NOLAN: Unless there is something that you would like to add to what you have already said, Dr. Brokaw, that will conclude what Dr. Brokaw has to say and he is now available for cross-examination.

THE CHAIRMAN: I would like to suggest, Mr. Nolan, that Mr. Brokaw's cross-examination may be deferred until we have heard Mr. Dixon. His subject matters are somewhat inter-related.

MR. NOLAN: They are of course inter-related.

THE CHAIRMAN: We could have Mr. Dixon present

his submission now, and have Dr. Brokaw recalled later.

MR. NOLAN: The report which will now be placed before the Board is entitled "Requirements and Supply of Natural Gas for Alberta and other markets." It might be marked as an exhibit.

DOCUMENT IN QUESTION NOW MARKED EXHIBIT J-13.

A. FAISON DIXON, examined by Mr. Nolan, testified:

MR. NOLAN: The Board will recollect, Mr. Chairman, that Mr. Dixon gave evidence before and was sworn, although he was not qualified I think at that time. Perhaps the Board - -

THE CHAIRMAN: We are prepared to accept Mr. Dixon's qualifications.

Q MR. NOLAN: Mr. Dixon, have you this Exhibit J-13 before you?

A Yes, sir.

Q And that is a study you prepared on the requirements of natural gas for the Province of Alberta and other markets?

A Yes, sir.

Q The introduction, I understand, you desire to read?

A Yes, sir.

Q Will you please proceed?

A INTRODUCTION

The problem before us is to determine in as much detail as is practicable the manner in which gas can be delivered from "presently existing fields" to furnish, first, gas for the needs of Alberta for thirty years, and, second,

gas for export for twenty years.

In order to bring such a study to a focus, we must consider many facts as proven, (some of which will be open to argument), and make assumptions on other matters which cannot now be proven or disproven. We believe all our assumptions are reasonable and in line with present trends.

For the purposes of this study we will consider the following facts to have been established. The annual consumption of gas and peak day demand in Alberta will be as shown on the accompanying tables. The total amount of gas to be exported will be 80 billion cubic feet per year in the fifth year with a coincidental peak day of 265 million cubic feet.

The gas reserves are those shown in the July, 1950, report of Dr. G. S. Hume, adjusted for abandonment pressure, impurities, field use and losses, and also adjusted upward in some cases where development since the date of the report has increased them.

Except for the Leduc fields, which I will consider separately, the amounts of gas that can be delivered from these fields are those shown in our exhibit entitled "Deliverability Study of Certain Alberta Gas Fields" by Albert D. Brokaw.

(Go to 360)

A In discussing the exercise of governmental authority, it is, of course, obvious that no one can know in advance what action that authority will take. Nevertheless, as the exercise of such authority will involve all other factors, we must make assumptions in order to have any basis for a quantitative study. These assumptions are: that the Alberta Government will exercise its full authority, if necessary, to see that the needs of Alberta are first met and then that gas is made available for export in the quantities shown.

A necessary corollary to this is that the gas fields so geographically situated as to make it economically feasible to interconnect them into one general source of supply will eventually be interconnected, if necessary, so that the gas sources of Alberta can be treated as a unit. Another necessary corollary is that all present or future contractual relations will be subordinated to the purposes to be served.

We do not believe that the exercise of such governmental authority will ever be necessary. It will prove more economical and better for all concerned for the two principal gas consuming areas of Edmonton and Calgary to take their gas from the presently connected fields through the present pipe-line systems, as long as such fields can supply the demand, and then from other fields connected together by a gathering system extending to many gas fields, creating a "grid system" serving both local and export demand. The gas for export will be derived chiefly from fields not now

connected with any large market. The gathering or grid system will be built to make it easy to interconnect all fields quickly so that the gas reserves, if necessary, can be treated as a unit.

The assumption that only the presently defined reserves will be available for provincial and export use is an assumption which is in our opinion supported by unanimous testimony, contrary to fact. It is hard to believe that many of the isolated gas wells will not develop into fields and that no new gas fields will be discovered. This must, of necessity, make any study such as this somewhat academic, but we hope, nevertheless, that it will be useful. If the presently defined reserves can meet the conditions of supplying this gas, then all future discoveries and extensions of outlying fields are in the nature of insurance. Our companies propose to build the necessary facilities to make possible the proposed interconnection of gas fields and markets as shown on the accompanying tables, together with such other fields as from time to time seem desirable and are approved by the authorities. This can be done by the construction of a grid system such as shown on our Exhibits No. 14 and 15 and schematic flow chart, Exhibit No. 28, with the probable change that the line south from Leduc will be 20 or 22 inches in diameter in place of 16 inches as shown.

Our companies contemplate, as an integral part of the project, the immediate construction of such a grid system.

We then tell the fields that we have covered and that we are not presenting Pincher Creek as of this moment as we think that the Gulf will have a study of that field that will be more authoritative than anything we can make.

Then on page 4 I reiterate that all these fields be interconnected with a grid system and form a common pool from which gas can be drawn to supply Alberta and export requirements.

Q MR. NOLAN: And you then set out the fields?

A I then describe certain fields we are not considering and we will start at the bottom of page 4.

Excess gas from Leduc and Jumping Pound will go into the grid and be available for local use and export. The grid system will be connected to local markets and towns within economic reach by interconnection with the present pipe lines. We believe that for many years these interconnections with the present system will be useful only in an emergency but eventually will be a means by which the Alberta communities, especially Calgary, will be able to receive gas from remote fields at low cost.

We will discuss the relative advantages of our proposed grid with that of the Alberta Inter-Field Gas Lines Limited, as presented in Exhibits No. 69 and 70 in the hearing of the Westcoast Transmission Company, Limited, before the Board.

A. F. Dixon,
Dir. Ex. by Mr. Nolan.

Next is a study of the deliverability of the Leduc-Woodbend fields.

STUDY OF THE DELIVERABILITY OF THE LEDUC-WOODBEND FIELDS

For several years I have been making studies of the probable future gas deliveries of gas fields where gas is associated with oil. I have had the privilege of being associated in this work with men of long practical experience in the operation of casinghead gasoline plants, where the estimates of future supply of gas from the fields connected to the plants were of vital importance. I have also had the help of men well qualified in the type of mathematical analysis used in making the calculations involved in this work. I have been able to check the estimates against results over a period of years. Changes in proration regulations make such checking difficult and the results are often inconclusive, but we believe the method used is helpful in attempting to solve an illusive problem.

As the gas and oil are produced from any field the pressure drops, and the ratio of gas to oil increases until the pressure reaches a low point, and then this ratio decreases.

I then describe the curve, which I do not think I need to read, but I would like to say that this curve is based on theoretical calculations checked by experience. I then give an illustration of the method of utilizing this theoretical gas-oil ratio curve against ultimate oil. That requires very close

reference back and forth to the curves and tables. I do not think it serves any special purpose to read it and I will start on the bottom of page 7.

Q Start at the beginning of the third paragraph on that page.

A Yes. Experience in other fields, then, has to be the guide in how far the relationship between the gas production and the oil production will vary from the theoretical. In a field where no gas cap exists and none develops to any marked extent as the field is depleted, this theoretical curve often proves an accurate guide for practical purposes.

In order to use the curve to determine the rate of withdrawal of the gas, the following must be known or assumed:

Recoverable oil reserves

Rate of withdrawal of the oil from the field

The gas-oil ratio is then calculated for a number of points, based on the percentage of the recoverable oil withdrawn, and a curve made; and from this curve and the rate of annual withdrawals the amount of gas coming out with the oil is calculated. This is shown in the tabulation and diagram on the following pages. As the field is depleted and records of gas-oil ratios are obtained, the curve can be corrected.

We have assumed withdrawals from the Leduc fields at the rate of 10,000 barrels per day from the D-2 formation, and 30,000 barrels per day from the D-3 formation until 75 per cent of the recoverable reserves

in each case have been produced, and then a decline at the rate of 10 per cent each year; i.e., we assume that after 75 per cent of the recoverable oil has been produced, each year's oil production will be 90 per cent of the preceding year's production.

This 40,000-barrel estimate of future production per day of Leduc is based on an estimated total production of Alberta, from present fields, of 160,000 barrels per day; one half from Redwater, one quarter from Leduc, and one quarter from other fields. We believe that under these conditions our estimate for the D-2 zone, where there is no gas cap, is reasonable.

In the case of the D-3 zone other conditions obtain. We have here a possible slight water drive and certainly a large gas cap. Experience in many other fields where similar conditions were met is our only criterion for judging the future. We can hope to preserve the gas cap completely only in fields that are completely unitized so that it is immaterial to the owners from which wells the oil is taken.

In such a unitized field, as soon as the gas cap begins to break into the oil column, raising the gas-oil ratio of a well, that well can be shut in and more oil taken from other wells. This process can be continued as more and more wells become high gas-oil ratio wells until there remain as oil wells only a few, and they will be producing all the oil from the field. This shutting off of high gas-oil ratio wells under ordinary conditions in a non-unitized field would permit a disproportionate amount

of oil to be produced from some leases. Wells on these favored leases would get the oil now underlying other leases, which would be an injustice to the owners of the less favored leases. We have not heard any suggestions to unitize the Leduc fields, and we will assume that it will follow the course of many other similar fields.

As the oil is depleted in the D-3 zone, the gas-oil ratio will rise at least as fast and probably much faster than it would if there were no gas cap (in theory, with no gas cap the gas-oil ratio should remain about constant, but it never does; we have evidence that it is already rising here).

The evidence that it has been rising is that if we take the D-2 zone using the figures taken from the Conservation Board in 1947, the gas-oil ratio from all wells, that is, taking the oil produced and the gas produced, was 388 cubic feet to a barrel. From all wells in 1948 it had risen to 506; in 1949 it had risen to 569 and up to August of this year to 614, and in the month of August to 658. That is for the D-2 zone. Now, in the D-3 zone, using the same method, in 1947 the gas-oil ratio was 461, then the Atlantic No. 3 blew wild so that it is very difficult to give any comparable figures for that year, that is, just against the oil produced and the gas produced. As measured, the oil-gas ratio was 390 cubic feet to a barrel, but after that well was controlled and things were going along more regularly again, the gas-oil ratio in 1949 had risen to 543, in 1950 up to August 31st, to

554, and for the month of August, 565. So that the theoretical condition of the gas cap holding the gas-oil ratio does not obtain here and it can not be expected to maintain as it in fact does. In all cases where you have a gas cap, that I am familiar with, the gas breaks into the oil wells and you have an increasing gas-oil ratio, and eventually the wells become chiefly gas wells with incidental amounts of oil.

(Go to page 368)

Q You are at the bottom of page 9, the words beginning, "When the field is depleted", the seventh line from the bottom?

A Yes. When the field is depleted to about 25 per cent of the original recoverable oil, it will be really a gas field with only incidental oil. The diagram and table on the following pages show our calculations based on the assumption that the gas field had no gas cap or water drive.

We will assume that the gas/oil ratio can be held down to this amount until 75 per cent of the recoverable oil is recovered. After this 75 per cent of the oil is recovered, we will assume that there will be so many wells producing gas with practically no oil that the field can be considered as a gas field capable of producing gas from a very large number of wells, and the deliverability will depend on the available market.

We have used the figures in Dr. Hume's report in making our calculations of recoverable oil and recoverable gas reserves.

The Lower Cretaceous formation of the Leduc field is gas bearing over an area of eleven sections and has a reserve of 155.3 billion cubic feet, according to Dr. Hume. This gas field overlies the D-2 and D-3 fields in a large part. As the D-2 and D-3 fields are depleted, there will be many wells that can be perforated in the Lower Cretaceous and make this gas available at small cost, and here, also, the deliverability will depend on the available market.

In general, our belief, based on the observation of similar type fields, is that for ten years, or possibly less, the casinghead gas will be produced with the oil somewhat at the rate we have indicated, and then there will be a great excess of gas seeking a market. If no market for this gas is at hand, the field will have to be shut in or large volumes of gas flared to recover a comparatively small amount of oil.

Now, I would like to go back one page here to our forecast of production and deliverability diagram. Now, Mr.Davis said.....

Q Just what are you referring to exactly, Mr. Dixon?

A I am referring to one page back, the page in front of page 10.

Q Thank you?

A Mr. Davis said that the gas cap should be conserved during a period of major oil production. This means that the gas may not become available for 20 or 30 years. Now, I would like to show the great similarity of Mr.Davis's estimate in places to ours, and where we differ in places, and the basis of our differences.

Q Yes?

A Mr.Davis has some figures on areas and thicknesses that are somewhat different from Dr. Hume's. In the case of the D-2 he has 15,000 acres, Dr. Hume has 17,000. The thicknesses are the same. He has 9% porosity,Dr. Hume has 10%. He had an abandonment pressure, Dr. Hume had an abandonment pressure of 250, Mr.Davis had an abandonment pressure of 300. This gives or makes a

difference in, 120 billion cubic feet with regard to Dr. Hume's estimate of producible gas and 84 billion for Mr. Davis's. And also when that comes down to the last point of the gas that can be recovered, Mr.Davis has 50 billion and Dr. Hume has 93.8 billion.

I have no way of knowing what figures Mr.Davis has used, whether they are more accurate than Dr. Hume's. He spoke of using Mr. Baugh's estimate which was over a year older than Dr. Hume's estimate. Of course, there was a great deal of development since then.

Then there are certain others in the D-3 zone. The differences are about of the same order.

And im the final result, if you will look at the bottom of the forecast of production and deliveries, we have a note giving Dr. Hume's estimates. Mr. Davis is 50 in place of 112 by Dr. Hume in the D-2. 206 in place of 301 in the D-3, and 531 in place of 603 in the D-3 gas cap. And he stated in his testimony that he believed that the Lower Cretaceous would produce, and corrected his former implication that it could not.

Now, that comes to 942 billion cubic feet for Mr. Davis against our 1 billion 121, pardon me, 1 trillion, 121 billion, sorry. We have used in making up our estimate for the gas to the pipe line 70% of the gas coming from the wells. That differs slightly from Mr. Davis who uses, I think, 60%, I think it is, from the oil wells, and 90% from the gas cap.

Now, the great difference is

one that it is very hard to get into an argument about, because none of us know, and that is the rate of production of the oil. If we knew that accurately I think we could make these estimates with great precision, but it is very hard to forecast the rate of oil production.

The regular method that I have used in testifying before the Federal Power Commission was to take the last allowable and assume that is going to last forever, but that is an assumption that we know is not true, but what else can you do? Now, we have taken or made the assumption that this oil will be produced at a rate that would supply the known amounts for the Province and for the pipe line. And that looks like what could be utilized by present known methods of transportation and refining.

Now, let us assume that the production of oil greatly increases in Alberta, doubles, and there is no immediate market outlet, that will then lower these figures and extend the life of the field, but, at the same time other fields will come in, so that as far as the Province is concerned I think we are making a very safe assumption here. It will either be from Leduc or from somewhere else that they have to get it, if they have to shut Leduc down on account of the proration to take an equal amount from different fields. I have left Redwater out of my calculations altogether, although I think eventually there will be some gas available there, but that depends on so many different features, chiefly upon how much gas or how much oil will be coming out per well. Whether or not you can utilize gas from

an oil field does not depend on the gas/oil ratio primarily, it depends on the amount of gas you can get out of each well. If you have a high gas/oil ratio, you can take a small amount of oil out of a well and operate economically; if you have a very large amount of oil coming out of a well with a small gas/oil ratio, that also will be economical. And that is a very difficult type of prophecy to indulge in in regard to Redwater, just how fast that oil will be coming out, so that we have left it out of our calculations altogether.

Now, to go back to our forecsst of the rate of delivery at the present time, or in August, there were 8762 barrels a day going out of the D-2 zone. We have estimated 10,000 barrels per day. In August in the D-3 zone about 22,000 barrels a day were being produced, and we have estimated 30,000 barrels per day.

In the case of the Turner Valley field, this is the page following page 10, we have based the estimates of production on the estimate supplied by the Canadian Western Natural Gas Company Limited, and we have estimated a production there for the next 30 years of 230 billion cubic feet. As Mr. Davis's estimate was 367, and his very able discussion of that showed so much more knowledge of the field tham I could hope to obtain, I would rather like to substitute his figures for mine, but we will keep our figures the same as they are here, and that gives us abiut another 100 billion cubic feet to spare.

Starting on page 11 we have made

an estimate of natural gas reserves of Alberta, which we hope will be of assistance to the Board in trying to clarify some of the testimony given by the other witnesses.

(Go to page 374)

A ESTIMATED NATURAL GAS REQUIREMENTS OF ALBERTA

An estimate of the future gas requirements of any region depends essentially on foreseeing the future on four counts.

1. The future population that can be served with domestic and commercial gas,
2. The presently existing industries that can and will use gas,
3. The industries that may develop in the future, and
4. Technological advances that might increase or decrease the usefulness of gas.

The second is the only one that can be measured and calculations made objectively. All who have given an opinion on this subject have settled this part neatly and, we think, correctly, by assuming that all Alberta industry that can use gas is now or shortly will be using gas as primary fuel.

The increase in population and the development of industries are not subjects that lend themselves to mathematical analysis that can stand up under critical examination. Populations rise, fall or remain static in an unforeseeable manner, and predictions, to be accurate, would need to be inspired prophesies and not calculated estimates.

THE CHAIRMAN: Mr. Nolan, do you want all this read? We are prepared to accept it without it being read.

MR. NOLAN: Whatever the Board would like.

THE WITNESS: I will let the whole thing go. Maybe those who have any interest have read it.

MR. McDONALD: I suggest that Mr. Dixon deal with page 13.

A I can answer questions on it without reading it. Do you want me to read it?

Q That deals with what was dealt with this morning?

THE CHAIRMAN: Would you like to get that on the record, Mr. McDonald?

MR. McDONALD: Yes.

A "Alberta would not seem well situated geographically to develop bulk commodity industries which involve high freight rates to move the products to market. The unique advantage which Alberta now has over other Canadian provinces is its oil and natural gas. With increases in those resources, associated industries will develop, including the refining of oil and the chemical industries dependent on the raw chemicals. These materials are butane and propane which are by-products of natural gas and oil. They are expensive to ship in their crude form and the industries requiring them are usually located near the source of this raw material. These products are only available in great quantities at the gasoline extraction plants of natural gas pipe lines. In other words, as these industries are attracted to Alberta, the oil and gas reserves will have to increase proportionately and will not involve any depletion of the visible gas supply. The new industries that are most assured will

"not come unless there is an increase in the oil and gas resources. Therefore, there need be no worry regarding these probable industries consuming gas that might be needed by other consumers."

Q MR. NOLAN: Then you go into a discussion of the estimates of the local companies?

A I do not see any necessity of reading any of that.

Q Then that is - -

A But I would like to read just one part here on page 17:

"We have used the estimate presented as Exhibit No. 42 in the Westcoast hearing as a basis for calculating the yearly requirements of Alberta. It is the highest estimate made as of that date. Such estimates by their very nature cannot be substantiated. They show an increase of 85 per cent over the actual consumption in 1949. The forecast appears to be a maximum."

Then the next page is the estimates made by the various engineering firms and companies.

Q It is really a comparison?

A Giving a comparison, as near as a comparison can be made. You will note that the estimates of Ford, Bacon & Davis, made for the Westcoast Transmission Company, and the Ebasco Services are considerably lower than any of the estimates made by the Subsidiaries of International Utilities.

Q MR. STEER: By that you mean the Canadian Western and Northwestern?

A Yes, sir. The estimate that was put in recently,

after this had gone to press, for the Calgary and Edmonton companies was 2 trillion 249 billion within reach of the grid. That is just under 5 per cent above the estimate we have used. In making this long range type of forecasting, I would say these two were practically the same.

Q Have you anything to say about the a verage of all these figures as compared to the one you are using?

A If we take the average of them all, it would be a great deal lower, obviously, than the figures we are using. Then we discuss "Peak Day Requirements" and give our method of calculating each load factor, based on the historical load factor of the two systems here.

Q And that brings you to the third paragraph on page 19, does it not?

A Yes. I would like to read that paragraph.

"As can be seen from the tabulation, 'Summary of Gas Reserves, Production and Deliveries, 1951-1980,' there will be consumed during the period, including export, shrinkage and losses, 4.4 trillion cubic feet, leaving 1.6 trillion cubic feet in the fields from which this gas has been withdrawn."

Mr. Davis, in his submission, said that in 1980, which is going beyond the task that was laid upon us by the Board, as we were supposed then to stop at 1980, still we have enough left to fulfil his requirements of 500 billion for Western and 750 for Canadian.

Now we come to the tables which I think are self-explanatory. These tables on the first

page are built up from the tables by Dr. Brokaw and myself, as shown on two pages beyond this. "Summary of Peak Day Capacities and Requirements" and the summary on the next page, the "Summary of Gas Reserves, Production and Deliveries". In the first column is the total raw gas reserve which is chiefly from Hume. The Annual net gas production is the same column as three pages back, shown next to the last column from the right. The daily amount of gas on the second column from the right - -

Q MR. C. E. SMITH: What table is this?

A Unfortunately we did not have these numbered.

Q In Summary of Gas Reserves, Production and Deliveries?

A A Summary of Gas Reserves, Production and Deliveries.

Q MR. NOLAN: The second column from the right, the figure is 133.4?

A That is a summation of all the fields reading from left to right.

MR. NOLAN: Mr. Dixon was explaining that that figure of 133.4 is to be found in the table three pages back, entitled "Estimated Future Consumption of Natural Gas in Millions of Cubic Feet," because at the right hand side at the top of the column under Average Day is the figure 133.4. That is right, is it not?

A Yes, sir.

MR. C. E. SMITH: At the moment I am neck and neck with you, Harry, but it will not be long.

A We have then here the Daily Net Gas Available to the Pipe Line, and that, I think, is somewhat self-explanatory.

Then the annual raw gas production, you will see the second column from the left, and the annual net gas production the last column on the right. One is the gas as it comes from the well and the other is our estimate of the amount of gas that can get into the pipe line. Now, taking over the second tabulation after page 19, "Estimated Natural Gas Requirements," as we have said this was taken from Exhibit 42. Exhibit 42 gives 31,500 billions as the consumption for 1946 for the Canadian Western and the area around it, and as 25,600 billions for the consumption in 1950. We have made a rather rapid rise from the 25 to the 31 in order to bring the consumption up to that point. 31.5 times 30, which they said should be the average considered for the consumption for the 30-year period and so that rise rather - I plotted a smooth curve up to the year 1980 so that the consumption would come to 31.5 times 30, or 945 billion cubic feet. The same method was used in the case of the Edmonton or the Northwestern, and the same method was used in the Province generally. And then on the other side is the calculated, is the addition of the columns showing the annual amounts of the peak day calculation, being based on the historical load factors as we found them in the record. We have as the end result that there are sufficient reserves and sufficient deliverabilities to fulfil the requirements of the Province and the export demand, using ordinary gas field practice and not taking into account any of the discoveries that have been made or any discoveries that will be made. We have shown

that gas could be exported at the rate of 80 billion per year for 20 years and all the requirements of the Province satisfied for a period of 30 years.

MR. NOLAN: I think that might be a convenient place to break off.

MR. C. E. SMITH: That last statement will look very good in the papers.

Q MR. NOLAN: The Summary of Gas Reserves, Production and Delivery, Mr. Dixon, in the second column, Total Raw Gas Reserves?

A Those are a summation of all the gas reserves that we have taken from the table and subtracted from it the production up to date.

Q MR. DAVIS: In other words, that is recoverable gas?

A Yes.

Q Not gas in place?

A No, it is recoverable gas.

Q It is recoverable?

A Yes. Not necessarily to the pipe line.

Q No, but producible?

A Producible.

Q Not left in the ground?

A Yes.

THE CHAIRMAN: Mr. Nolan, we have had a request from the Imperial Oil Company to permit their assistant manager, Mr. McKenzie, to appear and give evidence tomorrow morning. Mr. McKenzie had made arrangements to go East

some months ago and we would like to have the benefit of his evidence. I thought we might call him after Mr. Dixon has completed tomorrow morning and I do not imagine that will take very long.

MR. NOLAN: Not so far as Mr. Dixon's own presentation is concerned. It will be very short because we have read almost all of what we propose to read. Whatever you feel, sir. It is a pity sometimes to break in on an examination.

THE CHAIRMAN: It is, but apparently Mr. McKenzie would not be available otherwise.

MR. NOLAN: I see.

THE CHAIRMAN: His arrangements were made some months ago.

MR. NOLAN: Well we must try and meet his convenience.

MR. STEER: Mr. Chairman, Mr. Davis will be leaving tomorrow and he has some material which might be useful, if time can be obtained tomorrow to put it in.

THE CHAIRMAN: Have you any idea how long it will take?

MR. STEER: I should say 15 minutes or 20 minutes.

THE CHAIRMAN: Well, we will try and arrange it for the morning.

MR. STEER: Yes, sir.

(At this stage the hearing was adjourned until 9.30 A.M. November 3rd, 1950.)